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Simulations of the auroral signatures of Jupiter's magnetospheric injections

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Abstract

We report the evolution of ultraviolet auroral features located equatorward of the main emission appearing in the Hubble Space Telescope (HST) images of the northern and the southern Jovian hemisphere. We investigate the possibility that those ultraviolet auroral structures are associated with energetic particle injections. For this study, we compare the characteristics of the simulated auroral signature of plasma injections with the observed parameters of equatorward isolated auroral structures.

1. Introduction

Jupiter's ultraviolet auroral emissions are divided into four main components: the polar emissions, the main emission, the satellite footprints and the outer emissions. The morphology of the outer emissions can be either diffuse, arc-shaped or compact emissions. In the present study, we focus on outer emissions clearly detaching from the main emission and forming compact structures that are evolving regardless of the rest of the auroral emission. These auroral features were selected because they have the same appearance as the auroral signature of a clearly identified injection previously observed by Mauk et al. [2002] at Jupiter, based on simultaneous Galileo spacecraft and Hubble Space Telescope measurements.

1.1 Plasma injections

Mauk et al. [1997] reported the first detection of energetic particle injection in Jupiter observed with the Energetic Particles Detector (EPD) on board the Galileo spacecraft. During a plasma injection, the magnetic flux lost through cold plasma outflow is balanced by inward injection of flux tubes containing hot plasma from the outer magnetosphere. Mauk et al. [1999] performed a statistical analysis of these energy-time dispersed intensifications in energetic ions and electrons, based on Galileo EPD data, and found that energetic particle injections are commonly observed in the Jovian magnetosphere. Later on, Mauk et al. [2002] associated an isolated equatorward patchy auroral ultraviolet emission with energetic particle injections threading the same flux tube. Nevertheless this association is based on a single set of simultaneous observations.

The goal of the present study is to simulate the auroral signatures of plasma injections by considering that the precipitating energy could be provided to the ionosphere by pitch angle diffusion and whistler-mode waves through electron scattering. We use the concept of simulation described in Radioti et al. [2013]. We compare the length and the brightness of the simulated signature with the observed parameters. Following this comparison, we are able to test whether the aforementioned mechanism is responsible for the auroral emission and to infer the typical energy and the spectral index of the energy distribution of the electrons involved in the injection process.

2. Equatorward isolated auroral structures

The equatorward isolated auroral features (Figure 1) consist of quasi-corotating isolated structures spanning a region roughly bounded poleward by Jupiter's main emission, and equatorward by the magnetic footpath of Io.

Dumont et al. [2014] reported the first statistical study of Jovian auroral features possibly associated with signatures of magnetospheric injections. The authors examined the possibility that the selected UV auroral features are related to injection events in the Jovian magnetosphere, they statistically investigated the properties of the equatorward auroral emissions.

They demonstrated that the features studied and energetic particles injection measurements from Galileo spacecraft are present at the same location in the magnetosphere, indicating that the auroral features under study are most probably signatures of injections.

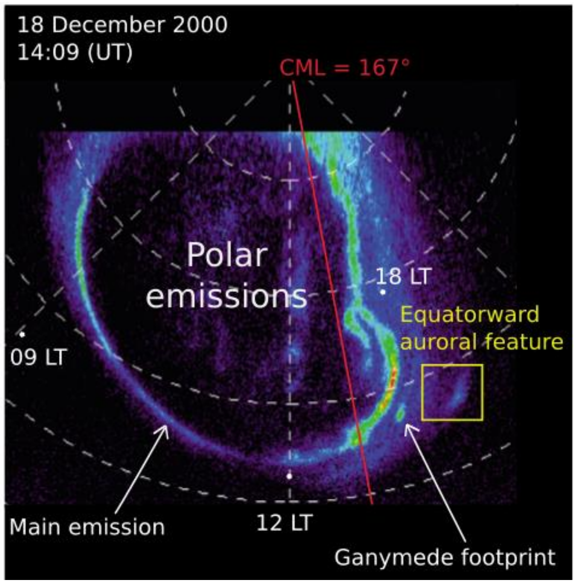

Figure 1: Polar projection of an HST/STIS image in a reference frame fixed in System III. The image shows the northern Jovian aurora on 18 December 2000 at 14:09 UT. The central meridian longitude (red line) is 167° System III. In this particular case, noon (12 LT) is approximately toward the bottom and dusk (18 LT) to the right. The main auroral features are indicated: the main emission, Ganymede footprint, polar emissions, and equatorward auroral feature.

3. Summary and Conclusions

In this study, we simulate the auroral signatures of plasma injections and we compare the characteristics of the simulated signature with the observed parameters. We analyze the temporal variations of the longitudinal extent and of the brightness of the auroral structures. Indeed, the injected charged particles drift at different rates due to energy-dependent gradient and curvature drifts, which leads to an increase with time of the longitudinal extent of the feature and of its associated auroral signature. Since the injected energy follows the same trend, the brightness decreases with time.

Different processes can generate auroral signatures of plasma injections. We simulate them by considering that pitch angle diffusion is generated by the precipitating energy flux in the ionosphere and whistler-mode waves through electron scattering. We compare the characteristics of the simulated signature with the observed parameters. Following this comparison, we are able to test whether the aforementioned mechanism is responsible for the auroral emission and to infer the typical energy and the spectral index of the energy distribution of the electrons involved in the injection process.

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